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Viewpoint
Nature Based Solutions for urban water management in Asian cities: integrating vulnerability into sustainable design

Nature Based Solutions (NBS) for urban water management seek to harness natural processes and (re) connect diverse flows in the urban water cycle for increased ecological sustainability. Developed in Australia, the US and Europe, the application of these approaches for urban water management tends to focus primarily on improving the environmental sustainability of grey water infrastructure. In many Asian cities, where the coverage of existing grey infrastructure is partial, and in some cases declining, the applicability of such approaches seems limited. That said, an engagement between NBS and the urban water challenges of Asian cities offers good reasons to expand NBS to address conditions of water vulnerability. In this Viewpoint, we take a particular interest in how NBS principles related to natural processes and alternative water supplies might be directed toward mitigating environmental harm in circumstances where urban residents are already reliant on non-networked and 'natural' services for water supply. We argue that improving infrastructure for sustainability in such cases requires thinking about how to limit the impacts of infrastructure inequalities on vulnerable residents and providing low-cost innovations that can work to protect and stabilise the non-networked ecological services on which millions of urban residents already depend.

Keywords: water, green infrastructure, urban politics, Nature Based Solutions, Asia

Introduction: global moves towards Nature Based Solutions for urban water challenges

In the most recent report of the United Nations World Water Assessment Program, released at the World Water Forum in March 2018, Nature Based Solutions (NBS) for water take centre stage. The report advocates 'working with nature' as essential to 'improve the management of water resources and achieve water security for all' by moving beyond what are termed 'conventional approaches' to water management (UN-Water, 2018). NBS is heralded as part of a move towards such 'green' infrastructure, a category that includes 'natural' processes in water management. The message is clear: NBS are necessary to solve the world's water challenges, problems which

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range from urban disaster risk to declining water availability or quality. At the same time, these 'green' approaches are contrasted with more conventional 'grey' infrastructure, which refers to the more centralised water management approaches, based almost entirely on engineering infrastructure solutions (UNEP-DHI, 2014).

Currently, to address problems of urban water quality and availability, NBS focus on increasing the sustainability of grey infrastructure by complementing it with green infrastructure techniques. But for cities in Asia and in the global South more broadly, where grey infrastructure is still partial, such solutions do not resolve threats to water security for the majority of residents reliant on ground or surface water flows. Using green infrastructure, or ecological processes, to improve the quality and quantity of water available through grey infrastructure will therefore not address the urban water challenges experienced by the majority of residents. Instead of waiting for the extension of grey infrastructure, and/or increasing the sustainability of what is there, we suggest that NBS be applied to address the implications of the grey infrastructure gap. This would require using NBS to mitigate declining quantity and quality of the water supplies of residents who are dependent on ecologically vulnerable 'natural' processes for their urban water security. We discuss this below in relation to scholarship on critical urban planning which makes an explicit call for considerations of equity and social justice to be integrated into any new urban water management paradigm (Allen et al., 2017).

This Viewpoint proceeds as follows. In the first section, we introduce NBS as a response to emerging limitations of urban water management reliant on grey water infrastructure, contrasting these limitations to those experiences by low-income residents of southern cities. In the subsequent section, we suggest that two key ideas from NBS – the consideration of ecological processes and the accent on alternative water supplies (AWS) – can be adapted to redress the impacts of grey water infrastructure for those with no or limited access to such networks. We conclude the section with a reflection on how any adapted NBS paradigm will need to engage with the complex politics of water and urban planning processes.

NBS and the limits of grey water infrastructure

The emphasis on NBS and 'green' sustainable solutions is not new within urban water management. Various planning paradigms have advocated the use of green infrastructure since the 1960s to ensure water quality and to manage the effects of effluent disposal (Ahern, 2007; Heaney et al., 2000). Approaches to NBS have evolved from an initial focus on integrated urban water management, which focuses on the management of urban water supply for both drinking and sanitation (Mitchell, 2006) to similar reformulations under the sustainable urban water management approach (Pahl-Wostl, 2002) or to the more recent interest in water sensitive cities and water-wise

cities (Wong and Brown, 2009; IWA, 2016). Common across these approaches is an emphasis on the benefits of integrating 'natural' ecological processes into urban water management and the development of alternative water supplies. These approaches have gained significant ground in recent years, being taken up at the international scale by organisations like the UN's World Water Assessment Programme as well as International Water Association, who see it as a key response to increasing urban water stress.

The common challenges identified by advocates of NBS include ageing infrastructure, depleted resources, and changing precipitation patterns in the context of growing and competing demands (Koop and van Leeuwen, 2017; McDonald et al., 2014) and climate change and urbanisation (Burn et al., 2012). For Asian cities in particular, climate change scenarios highlight the probability of increased and more erratic precipitation leading to intense floods and protracted droughts (Keath and Brown, 2008), changes in hydrological systems affecting the quality and quantity of water resources (IPCC, 2014) and declining water quality due to changes in sediment loads, evaporation rates and salinity (Delpla et al., 2009). As evident in the cases presented across cities in Asia in this special issue, challenges that climate change present in achieving 'water access for all' are being taken up in distinct ways (Devadiga, 2019; Lamb, 2019) with implications for not only water governance but for re-defining and imagining the city (Marks and Elinoff, 2019).

The universal applicability and suitability of grey water infrastructure to meet current urban water challenges is being questioned from other quarters as well, including those working from a critical urban planning or urban studies perspective. After decades of emphasising the 'ideal' of universal, uniform and centralised grey infrastructure services, the majority of people living in cities worldwide still continue to access water – of unreliable quality and availability – through a variegated landscape of providers and sources (Satterthwaite, 2016). Moreover, the drive to implement the 'ideal' has led to certain perverse and unintended consequences such as increased spatial segregation and sprawl (Jaglin, 2008), reduced water access for vulnerable groups (Birkenholtz, 2013), and limited efforts to foster a diversity of supply alternatives (Pflieger and Matthieussent, 2008; Maldonado, 1991).

Planners working in cities with different historical trajectories, often complicated by experiences of colonialism, advocate embracing the diversity that characterises urban water supply in these contexts. Writing from the context of cities in southern Africa, Sylvy Jaglin (2014, 434) explains that what is needed is:

> a radical change in perspective, taking as a starting point not the failure of urban services and the institutions responsible for their delivery, but the vitality and multiplicity of actual delivery systems which, despite policy announcements and reforms, and notwithstanding imported models, survive and contribute to the functioning of cities.

Appeals like Jaglin's resonate with critical urban planning scholarship, which make an explicit call for considerations of equity and social justice to be integrated into any new urban water management paradigm (Allen et al., 2017). Indeed, it is a key element of the critical scholarship on water, infrastructure and cities that each are produced through power relations and are thus inherently political. In work on water in political ecology, urban studies and science and technology studies, issues of power and urban exclusion have been well analysed and documented (e.g. Swyngedouw, 2004; Von Schnitzler, 2017). Recently, southern scholars have come together to argue for new ways of thinking that engage both openly and relationally with southern experiences (Watson, 2009; Parnell and Robinson, 2012; Pieterse, 2011). In our own work, we have sought to draw attention to the role of ecological processes and the interconnected flows of different waters within and beyond networked infrastructure in producing and reinforcing urban water injustice (Furlong and Kooy, 2017).

Rethinking NBS to incorporate key challenges in Asian cities

The above issues and critiques are not generally the focus of NBS scholarship. Indeed, 'natural approaches' like NBS, green infrastructure and water sensitive cities tend to take a technical approach not only to infrastructural questions but also to the 'governance' issues often thought to constitute the 'real barriers' to change (e.g. van de Meene et al., 2011, 1118). Yet, there are ideas central to NBS that can be used to think about how NBS might be extended for the mitigation of certain key water challenges in Asian cities. We focus on two. The first and most obvious is harnessing ecological processes, and the second is thinking about alternative water supplies to that of traditional piped water. Below we explore these two ideas for how they can be adapted to redress some of the key water inequalities linked to ecological vulnerabilities in cities in Asia. Yet, none of this is simple. As such, we conclude this section by considering the implications of decentralised water supply systems and the diversity of providers for water planning practices in seeking to adapt ideas from NBS.

Ecological services: paying attention to the impact of integrated flows

First, the desired transition to water sensitive cities relies on 'ecological services' organised via a range of 'green infrastructure' solutions. Urban green infrastructure is increasingly being used to manage and reduce pollution by channelling and treating storm water or wastewater through wetlands, and other 'natural' treatment processes to remove pathogens. Examples include green walls, roof gardens and vegetated infiltration or drainage basins to support wastewater treatment and reduce storm water runoff. Through such processes, it is anticipated that urban water management will not only become more ecologically sustainable, it will use 'natural' ecological

services to do so. For Asian cities, the harnessing of these processes should be explicitly targeted at mitigating the effects of flows negatively impacting the non-networked water supplies of vulnerable urban residents. This is in terms of both quality and quantity (including insufficient supply and flooding), issues which can often be interconnected.

Following the flow of groundwater through cities provides one illustration of how diverse water use practices and flows can have adverse impacts on water supplies in other areas. We highlight these ecological connections between urban water flows as relevant for NBS designs using the case of Jakarta, where more than 60 per cent of residents rely on groundwater for all or part of their domestic supply. However, while expensive high-rise complexes, businesses and industries can afford to extract clean water from the deep aquifer, most residents can only access the contaminated water of the shallow sub-surface (Kooy et al., 2018). Groundwater pumping across the city contributes to land subsidence, salt-water intrusion, shallow groundwater salinisation and flooding in the northern coastal areas of the city (Abidin et al., 2011). Unsurprisingly, the impacts of these interconnected activities are uneven. The city's poorest residents, living on the most marginalised land, experience higher exposure to flooding, have access to poorer quality water, and are less able to invest in household water treatment technologies.

With these types of integrated urban water flows in mind, NBS interventions should be designed to reduce the vulnerability of residents already dependent on ecological services for water supply. As opposed to giving priority to increasing the sustainability of grey infrastructure, the needs of residents who rely on groundwater or surface water not contained by grey infrastructure and whose supply is degraded through interaction with other water flows (from distant groundwater extraction, to accumulating plastic waste, to wastewater flows) should be central in modelling impacts and design.

Alternative water supplies

Second, NBS calls us to think about new sources of water supply. Indeed, the NBS approach implies a major change in how we manage and relate to water: wastewater and storm water are no longer viewed as disposable 'harmful' waters but seen as alternative, more sustainable, forms of water supply (Meehan et al., 2013; Ormerod and Scott, 2013). The integration of these water flows is argued to 'close the urban water cycle'. For the urban water management community, this marks a paradigm shift away from the dominant linear and centralised approach to water and wastewater reliant on grey infrastructure, towards integrated ecological approaches for the management of all urban water sources and systems (GWP, 2013; IWA, 2016). Again, for Asian cities, alternative water supply ideas can be used to recognise the importance

of non-networked supplies for millions of residents and thus to think about how to protect and improve them.

Heeding Jaglin's call to recognise that 'informal' supplies are in many cities dominant and long-term (2014), recognising them as forms of AWS is important for garnering the support and attention they need to be both safe and sustainable. This means working to protect the quality, reliability and quantity of these supplies as they are affected by the wastewater and storm water flows insufficiently captured in Asian cities, or degraded through environmental activities. Devising and providing technologies to secure and improve these water sources could range from household treatment devices to rainwater harvesting systems.

Still, AWS techniques not only need to be adapted to the specific conditions and needs of users beyond the network but also to conditions of poverty and inequality, which means they should not become another tool where responsibility for clean and reliable water is privatised to the individual or the household level. Green infrastructure and NBS should work to adapt AWS like rainwater harvesting, groundwater and surface water self-supply, various forms of in-home treatment, and water delivery to make them part of the public supply, despite their decentralised nature (see also Devadiga, 2019). This means that they would be subject to public programmes of water quality monitoring, as well as public finance initiatives to increase equitable access.

The politics of planning processes

In current NBS approaches to urban water management the word 'governance' is often used as a generic term that flattens complex socio-political and economic processes. This is perhaps even more pertinent in cities in the global South where issues of inequality are central. Thus, any programme for NBS must not only complicate their approaches to governance but also engage with the reality of planning and development practices in cities. Interventions to secure the quality and quantity of diverse water flows require an understanding of how current practices and social relations shape existing forms of water vulnerability. Rather than a strict focus on the official policies and sector plans for urban water management, NBS that addresses vulnerability must look beyond these to the practices through which water is actually made to flow in cities, and confront the uneven social relations shaping them. We highlight some examples below.

In Ghaziabad, a city on the outskirts of Delhi, India, it is common knowledge that the discharge of industrial and domestic wastewater adjacent to low-income peri-urban settlements degrades surface and groundwater quality (Karpouzoglou et al., 2018). These practices are not the result of a lack of policies or environmental regulation (formal institutions), but are rather highly formalised yet unoffi-

cial arrangements made between environmental agencies, industrial and commercial developers, and the political elite (Karpouzoglou et al., 2018). Likewise, in Indonesia, it is arrangements made between political and economic elites and spatial planning agencies that allowed the illegal conversion of the protected watershed into elite villas and commercial housing upstream of Jakarta (Leaf, 2015). This deforestation has decreased the carrying capacity of rivers, exacerbating downstream flooding and the subsequent contamination of the shallow groundwater sources used by low-income urban riverside settlements (Vollmer and Gret-Rheamy, 2013). Through the same set of elite networks in Indonesia, conversion of mangrove forests to high end commercial real estate in North Jakarta over the 1980–90s removed natural flood protection and water filtration, while at the same time creating new, high volume, and politically protected, users of deep groundwater whose over abstraction further degrades surface and shallow groundwater supplies (Rukmana, 2015).

These politics of urban planning, not unique to cities in Indonesia or India, matter for urban water management. Such moves have led to increased flood risk, and salinisation of shallow groundwater--on which low-income residents are reliant--due to over extraction of deep groundwater and subsequent land subsidence. It is these land development and planning practices, often outside of the water sector, which shape current pernicious interactions between wastewater, drinking water supply and storm water. These practices of land development and spatial planning are considered largely outside of the sphere of the water service providers, but they are – we argue – where planning the water sensitive city and designing NBS needs to start (e.g. Chung et al., 2018; Douglas, 2018). The design of NBS for urban water challenges therefore needs to look beyond the water sector, and beyond the written norms and regulations to engage explicitly with the politics of how things are done in practice.

Conclusion

Globally, the majority of urban residents already rely on 'nature' for their water supply outside of but not necessarily uninfluenced by existing networks of grey infrastructure. While this is not the traditional focus of nature based solutions, we argue that there are opportunities here for NBS approaches which acknowledge and engage with these pervasive, diverse and often informal water supply systems. These supplies, however, do not exist in an ecological bubble immune from water management practices elsewhere in the city. Thus, for NBS designs to be effective in Asian cities, and not exacerbate existing water vulnerabilities, they need to be adapted to address the implications of the 'grey gap' for those urban residents who are most vulnerable to degradation of water quality and quantity, by wider urban water management practices. This means, engaging concepts of 'ecological services' and 'alternative

water supplies' in protecting, stabilising and rehabilitating the non-networked water supplies of the most vulnerable urban residents.

Such an approach implies a recognition of the politics of urban nature, a constant questioning of who benefits from proposed NBS and who does not, and who has created the environmental externalities NBS are proposed to address. Such questions are currently obscured in policy language and the promises of win-win solutions. Yet, as critical urban environmental planning research has endeavoured to show over the decades, the ecological is neither natural, nor neutral. These realities need to be faced if sustainable urban water management solutions are to avoid reproducing the same inequalities that their predecessors not only failed to redress but often exacerbated.

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